There were no Category 1 or 2 indicators available for *ecological processes* or *natural disturbance regimes* for fresh waters. Limnologists have long measured primary productivity in lakes, and nutrient spiraling and leaf-pack decomposition in streams, but no systematic data were available in the form of an indicator for this report. Phenomena involved in natural disturbance regimes in fresh waters include hydrology (e.g., low-flow frequencies, floods), time of ice-out in lakes, and fires and other factors that affect watersheds.

5.7 What Is the Ecological Condition of Coasts and Oceans?

The coasts and oceans of the United States extend from the shoreline out approximately 200 miles into the open ocean. The indicators in this report, however, focus on estuaries and coastal waters within 25 miles of the coast. Coastal ecosystems are productive and diverse, and include estuaries, coastal wetlands, coral reefs, mangrove forests, and upwelling areas. Critical coastal habitats provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. Coastal areas are also sinks for pollutants transported through surface water, ground water, and atmospheric deposition.

Coastal areas are among the most developed areas in the nation. Coastal areas comprise 17 percent of total conterminous U.S. land area, yet these areas are home to 53 percent of the U.S. human population. The coastal population is increasing by about 3,600 people per day, giving rise to a projected total increase of 27 million people between 2000 and 2015 (U.S. Census Bureau, 2002).

Coastal areas also contribute significantly to the U.S. economy. Almost 31 percent of the Gross National Product is produced in coastal counties (EPA, ORD, OW, September 2001). Almost 85 percent of commercially harvested fish depend on estuaries and adjacent coastal waters at some stage in their life cycle (NRC, 1997). About 180 million people use coastal beaches each year (Cunningham and Walker, 1996). Estuaries supply water, receive discharge from municipal and industrial sources, and support agriculture, commercial and sport fisheries, and recreational uses such as swimming, and boating.

National estuarine and coastal monitoring programs have been in place for 15 to 20 years. A number of agencies and programs provide information on the condition of coastal waters and wetlands, including the National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends Program, National Estuarine Research Reserve System, and National Marine Fisheries Service National Habitat Program; EPA's National Estuary Program and Environmental Monitoring and Assessment Program; and the Fish and Wildlife Service National Wetlands Inventory and Coastal Program.

In 2000, EPA, NOAA and USGS, in cooperation with all 24 U.S. coastal states, initiated the National Coastal Assessment (also known as Coastal 2000 or C2000). Using a compatible, probabilistic design and a common set of survey indicators, each state conducted

Exhibit 5-32: Coasts and oceans indicators

Essential Ecological Attribute	Indicators	Category		Source
Landscape Condition		I	II	
Extent of Ecological System/Habitat Types	Extent of estuaries and coastline	■		EPA
Landscape Composition	Coastal living habitats		■	DOI
	Shoreline types		■	DOC
Landscape Structure/Pattern				
Biotic Condition				
Ecosystems and Communities	Benthic Community Index		■	EPA
	Fish diversity		■	EPA
	Submerged aquatic vegetation		■	EPA
Species and Populations	Chlorophyll concentrations		■	EPA
Organism Condition	Fish abnormalities		■	EPA
	Unusual marine mortalities		■	DOC
Ecological Processes				
Energy Flow				
Material Flow				
Chemical and Physical Characteristics				
Nutrient Concentrations	Total nitrogen in coastal waters		■	EPA
	Total phosphorous in coastal waters		■	EPA
Other Chemical Parameters	Dissolved oxygen in coastal waters		■	EPA
	Total organic carbon in sediments		■	EPA
Trace Organics and Inorganics	Sediment contamination of coastal waters		■	EPA
	Sediment toxicity in estuaries		■	EPA
Physical Parameters	Water clarity in coastal waters		■	EPA
Hydrology and Geomorphology				
Surface and Ground Water Flows				
Dynamic Structural Conditions				
Sediment and Material Transport				
Natural Disturbance Regimes				
Frequency				
Extent				
Duration				

Note: MAIA indicators included pending completion of peer review

the survey and independently assessed the condition of their coastal resources. These estimates currently are being aggregated to assess the condition of the nation's coastal waters. While the first complete assessment of the nation's coastal waters will be available in 2003, a preliminary assessment of selected estuarine systems was published in 2001 (EPA, ORD, OW, September 2001).

Exhibit 5-32 lists the ecological indicators of coastal condition used in this report. Eight indicators are discussed in Chapter 2, Purer Water. The indicator *Chlorophyll Concentrations* deals with biotic structure of phytoplankton communities, and the rest are associated with the chemical and physical characteristics of coastal ecosystems. These eight indicators are summarized below. The section then presents nine indicators that appear for the first time in this report. Two involve the coastal landscape, and the rest involve the biotic structure of coastal ecosystems. There are no indicators of ecological processes, hydrology and geomorphology, or natural disturbance regimes with data suitable for national or regional reporting.

The following indicators presented in previous chapters relate to the ecological condition of coasts and oceans:

- The indicator *Chlorophyll Concentrations* is a measure of the abundance of phytoplankton. Excessive growth of phytoplankton, as measured by chlorophyll concentrations, can lead to degraded water quality, such as noxious odors, decreased water clarity, andoxygen depletion. Excess phytoplankton growth is usually associated with increased nutrient inputs (e.g., watershed or atmospheric transport, upwelling) or a decline in filtering organisms such as clams, mussels, or oysters (The Heinz Center, 2002).

  Average seasonal ocean chlorophyll concentrations (within 25 miles of the coast) ranged from 0.1 to 6.5 ppb (The Heinz Center, 2002). The highest ocean chlorophyll concentrations (4.8 to 6.5 ppb) were in the Gulf of Mexico with the lowest concentrations in Hawaiian waters (0.1 ppb). Southern California had the next lowest chlorophyll concentrations, between 1.1 and 1.5 ppb. Other ocean waters (e.g., north, mid-, and south Atlantic, and Pacific Northwest) had chlorophyll concentrations ranging from 2 to 4.5 ppb.

  Estuarine chlorophyll concentrations were not available for national reporting in the Heinz report, but chlorophyll concentrations in the mid-Atlantic estuaries ranged from 0.7 to 95 ppb in 1997 and 1998 (EPA, ORD, May 2003). EPA established three categories: good <15 ppb; fair 15-30 ppb; and poor >30 ppb. The lower threshold of 15 ppb chlorophyll is equal to the restoration goal recommended for the survival of submerged aquatic vegetation (SAV) in the Chesapeake Bay (Batiuk, et al., 2000). About 33 percent of the mid-Atlantic estuarine area had chlorophyll concentrations exceeding 15 ppb. The Delaware Estuary showed a wide range of chlorophyll concentrations, from low in the Delaware Bay (<15 ppb) to intermediate in the Delaware River (15 to 30 ppb) to very high (>80 ppb) in the Salem River. The western tributaries to the Chesapeake Bay were consistently high in chlorophyll, with more than 25 percent of the area showing >30 ppb chlorophyll concentrations. Chlorophyll concentrations in the coastal bays were generally low (< 15 ppb), even though nutrients were elevated, because of increased turbidity and low light penetration.

- The *Water Clarity in Coastal Waters* (Chapter 2, Purer Water) indicator is important for maintaining productive systems in good condition and is affected by chlorophyll concentrations. Light penetration is important for submerged aquatic vegetation (SAV), which serves as food, nursery, shelter, and refugia habitat (areas that provide protection from predators) for aquatic organisms. EMAP measured water clarity using a light penetrometer, which recorded the amount of surface light that penetrated to a depth of 1 meter (EPA, ORD, OW, September 2001). Water clarity was considered poor if less than 10 percent of surface radiation penetrated to 1 meter. Water clarity was considered fair if there was between 10 and 25 percent penetration, and clarity was considered good if there was greater than 25 percent penetration. Data were collected for all conterminous estuaries in the U.S. The 10 percent light penetration at 1 meter is required to support SAV, which is an ecological endpoint in several estuarine ecosystems. Overall, 64 percent of the nation's estuarine area had light penetration of at least 25 percent at 1 meter (EPA, ORD, OW, September 2001). Only 4 percent of the nation's estuarine area had poor light penetration (less than 10 percent).

- Nitrogen, and less often phosphorus, control the chlorophyll concentrations in coastal ecosystems. The indicator *Total Nitrogen in Coastal Waters* (Chapter 2, Purer Water), was calculated for the mid-Atlantic estuaries by summing the concentrations of total dissolved nitrogen and particulate organic nitrogen (EPA, ORD, May 2003). Assessment categories were determined based on the 25th and 75th percentiles because there are no total nitrogen (TN) criteria for estuaries. The categories are: low < 0.5 ppm N; intermediate 0.5 to 1.0 ppm N; and high > 1.0 ppm N. About 35 percent of the mid-Atlantic estuarine area had low TN concentrations, 47 percent had intermediate TN concentrations, and 18 percent had high TN concentrations. About 50 percent of the mainstem area of the Chesapeake Bay had low TN concentrations, with only about 5 percent having high TN concentrations. The coastal bays, in contrast, had about 5 percent of their area with low TN concentrations and about 35 percent with high TN concentrations. The Delaware River estuary portion of Delaware Bay had 100 percent of its area with high TN concentrations.

- The indicator *Total Phosphorus in Coastal Waters* (Chapter 2, Purer Water) assessment categories were based on the 25th and 75th percentile concentrations measured throughout the mid-Atlantic. These categories are: low < 0.05 mg P/L; intermediate 0.05 to 0.1 mg P/L; and high > 0.1 mg P/L. Total phosphorus (TP) concentrations ranged from 0 to 0.34 mg P/L. About 58 percent of the mid-Atlantic estuarine area had low TP concentrations, 30 percent had intermediate, and 12 percent had high TP concentrations (EPA, ORD, May 2003). About 85 percent of the mainstem area of the Chesapeake Bay had low TP

concentrations, with no areas having high TP concentrations. The coastal bays, in contrast, had no areas with low TP concentrations and about 35 percent with high TP concentrations. The Delaware River estuary portion of Delaware Bay had 100 percent of its area with high TP concentrations.

- Dissolved oxygen is depleted when phytoplankton in estuaries die and decompose. Data on the *Dissolved Oxygen in Coastal Waters* indicator (Chapter 2, Purer Water) were reported primarily for estuaries in the Virginian, Carolinian, and Louisianian Provinces[16]. Dissolved oxygen in these estuaries was reported as good because 80 percent of estuarine waters assessed were estimated to exhibit dissolved oxygen at concentrations greater than 5 ppm (EPA, ORD, OW, September 2001). Hypoxia resulting from anthropogenic activities is a relatively local occurrence in Gulf of Mexico estuaries; only 4 percent of the combined bottom areas in these estuaries is hypoxic. The occurrence of hypoxia in the shelf waters of the Gulf of Mexico is more significant. The Gulf of Mexico hypoxic zone is the largest area of anthropogenic coastal hypoxia in the western hemisphere (CAST, 1999). Since 1993, mid-summer bottom water hypoxia in the Northern Gulf of Mexico has been larger than 3,860 square miles and in 1999, it reached over 7,700 square miles (CENR, 2000).
- *Total Organic Carbon in Sediments* (Chapter 2, Purer Water) is often an indicator of organic pollution (e.g., from decomposing phytoplankton blooms or waste disposal). Total organic carbon (TOC) values are calculated as percent carbon in dried sediments. Values ranged from 0.02 to 13 percent carbon (Paul, et al. 1999). Assessment categories for the mid-Atlantic estuaries were tentatively set at: low 1 percent; intermediate 1 to 3 percent, and high >3 percent, but they are still under evaluation. For the mid-Atlantic region, about 60 percent of the sediments had low TOC values, about 24 percent had intermediate TOC values, and 16 percent had high sediment TOC values (EPA, ORD, May 2003). Values ranged from those of Delaware Bay, with about 95 percent of its sediments having low TOC values, to those of the Chowan River in the Albemarle-Pamlico Estuary with 65 percent of its sediments having high TOC values (EPA, ORD, May 2003). The Chesapeake Bay mainstem had about 65 percent of its sediments with low TOC values and about 15 percent with high TOC values.
- The *Sediment Contamination of Coastal Waters* indicator (Chapter 2, Purer Water) was analyzed in estuaries primarily along the Atlantic Coast and Gulf of Mexico as part of the EPA EMAP Estuaries Program. Results from these analyses indicated that 40 percent of estuarine sediments in these areas were enriched in metals from human sources, 45 percent were enriched in PCBs, and 75 percent were enriched in pesticides (EPA, ORD, OW, September 2001). The highest concentrations of all three constituents were found in South Florida sediments with 53 percent, 99 percent, and 93 percent of the sediment area enriched in metals, PCBs, and pesticides, respectively.
- The EPA EMAP Estuaries Program, in conjunction with the NOAA Status and Trends Program, developed the indicator *Sediment Toxicity in Estuaries* (Chapter 2, Purer Water). The EMAP Estuaries Program found that about 10 percent of the sediments in the Virginian, Carolinian, Louisianian, West Indian, and Californian Province estuaries were toxic to the marine amphipod *Ampelisca abdita* over a 10-day period (EPA, ORD, OW, September 2001). The NOAA Status and Trends Program also used a sea urchin fertility test and a microbial test to evaluate chronic toxicity in selected estuaries. NOAA found that 43 to 62 percent of the sediment samples from the selected estuaries showed chronic toxicity (EPA, ORD, OW, September 2001).

On the following pages, several indicators are introduced for the first time in this report that relate to the essential ecological attributes of landscape condition and biotic condition of estuaries.

[16] Provinces are biogeographical regions with distinct faunas.

Indicator: Extent of estuaries and coastline - Category 1

Estuarine areas provide habitat for organisms which contribute significantly to the national economy. These areas also are under pressure from the 53 percent of the U.S. population that lives within 75 miles of the coast. Estuarine areas and coastline include brackish water bays and tidal rivers, which are influenced by the mixing of fresh water and ocean salt water in these areas. Extent estimates were provided by the coastal states as part of the EPA National Water Quality Inventory - 2000 Report (EPA, OW, August 2000).

What the Data Show

EPA estimates that the U.S. and its territories have 95.9 million acres of estuarine surface area and about 58,618 miles of coastline (EPA, OW, August 2002).

Indicator Gaps and Limitations

These data were compiled from inventories performed by the states. Differences in how each state defines estuaries are likely, so the consistency of the inventory is unknown.

Data Source

The data source for this indicator was the *2000 National Water Quality Inventory,* U.S. Environmental Protection Agency, August 2002. (See Appendix B, page B-45, for more information.)

Indicator: Coastal living habitats - Category 2

This indicator provides the acreage of vegetative habitat such as submerged aquatic vegetation (SAV), mangrove forests, and coastal wetlands. Vegetation not only stabilizes the habitat, but also provides food, shelter, nursery areas, and refugia for other aquatic organisms. Loss of coastal habitat is a major contributor to the loss of both economic and non-marketable aquatic species (The Heinz Center, 2002).

What the Data Show

The USFWS National Wetlands Inventory (NWI) estimates more than 5 million acres of coastal wetlands contribute to the diversity of coastal habitat (Exhibit 5-33). Wetland acreage declined about 8 percent from the mid-1950s to the mid-1990s (The Heinz Center, 2002). Out of 5 million total acres, 400,000 acres of coastal wetland were lost over this period, although the loss rate declined in the 1990s (The Heinz Center, 2002).

Indicator Gaps and Limitations

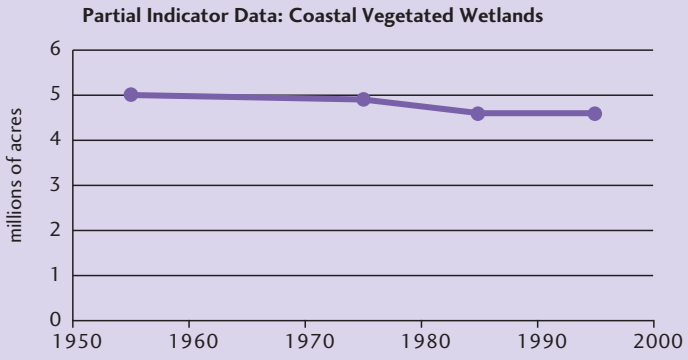
Data for coral reefs and seagrasses and other SAV are available for many areas, but these data have not been integrated to produce a national estimate. Different approaches have been used to estimate some of these coastal habitats which make make integration difficult. For example, estimates of the extent of SAV are noted in some regions only as presence/absence, while the area is estimated quantitatively in other regions. Data for vegetated wetlands are available for only the East and Gulf Coasts.

Data Source

The data source for this indicator was *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997*, Dahl, 2000, utilizing data from the National Wetlands Inventory. (See Appendix B, page B-45, for more information.)

Exhibit 5-33: Coastal living habitats, 1950s-1990s

Data Not Adequate for National Reporting on:
- Seagrasses/Submerged Vegetation
- Shellfish Beds
- Coral Reefs
- Wetlands in Other Regions



Coverage: Atlantic and Gulf Coasts Only

Source: The Heinz Center. *The State of the Nation's Ecosystems.* 2002. Data from the U.S. Fish and Wildlife Service.

Indicator

Shoreline types - Category 2

This indicator includes the miles of coastline in different categories, such as beaches, mud or sand flats, rock or clay cliffs, and wetlands. It also includes coastline that is protected with engineered structures such as armoring or riprap. Loss or conversion of shoreline habitat to armoring or riprap can eliminate the habitat required by various organisms for spawning, gestation, nursery area, feeding, or refugia.

What the Data Show

Over two-thirds of the mapped shoreline in the south Atlantic, southern California, and Pacific Northwest is coastal wetlands, with most of the coastal wetlands occurring in the South Atlantic (The Heinz Center, 2002) (Exhibit 5-34). Three-quarters of the south Atlantic shoreline is wetlands (The Heinz Center, 2002). Beaches account for about 33 percent of the shoreline in both southern California and the Pacific Northwest. Southern California, however, has a much lower percentage of wetlands and mud or sand flats than the Pacific Northwest. Steep shorelines, mud flats, and sand flats each make up the smallest portion of the total in all three regions. Armored shorelines, which inclde bulkheads and rip rap, account for about 11 percent of miles of the total coastline.

Indicator Gaps and Limitations

Estimates of shoreline types are not available for the entire U.S., including much of the Atlantic and Gulf Coast areas. Some of the atlases used to compile this information are more than 15 years old. Coastal areas are dynamic and change over time, so the accuracy of available estimates is unknown.

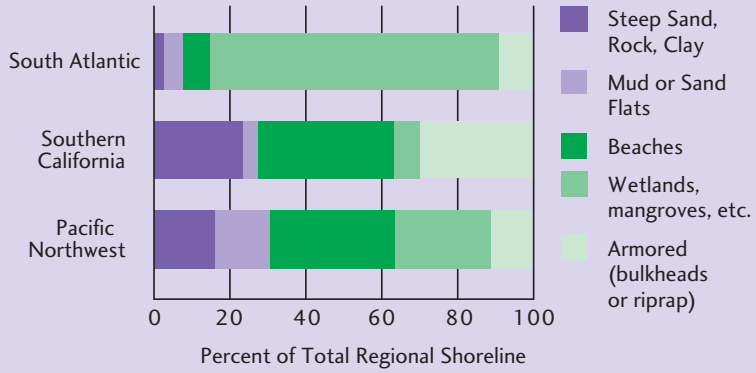
Data Source

The data source for this indicator was the *Environmental Sensitivity Index Atlases,* National Oceanic and Atmospheric Administration (1984-2001). (See Appendix B, page B-46, for more information.)

Exhibit 5-34: Coastal shoreline types, 2000

Data Not Adequate for National Reporting on:
- North Atlantic
- Mid-Atlantic
- Gulf of Mexico
- Gulf of Alaska
- Bering Sea
- Hawaii

Partial Indicator Data: Shoreline Types by Region



Coverage: Pacific Northwest, Southern California, and South Atlantic Regions only

Source: The Heinz Center. *The State of the Nation's Ecosystems.* 2002. Data from the National Oceanic and Atmospheric Administration.

Indicator Benthic Community Index - Category 2

EMAP Estuaries Program has developed indices of benthic condition for estuaries in the conterminous U.S. (Engle and Summers, 1999; Engle, et al., 1994; Van Dolah, et al., 1999; Weisberg, et al., 1997). Benthic macroinvertebrates include annelids, mollusks, and crustaceans that inhabit the bottom substrates of estuaries. These organisms play a vital role in maintaining sediment and water quality, and are an important food source for bottom-feeding fish, invertebrates, ducks, and marsh birds. Measures of biodiversity and species richness, species composition, and relative abundance or productivity of functional groups are among the assemblage attributes that can be used to characterize benthic community composition and abundance. The Heinz report refers to this indicator as Condition of Bottom-Dwelling Organisms (The Heinz Center, 2002).

Assemblages of benthic organisms are sensitive to pollutant exposure (Holland, et al., 1987, 1988; Rhoads, et al., 1978; Pearson and Rosenberg, 1978; Sanders, et al., 1980; Boesch and Rosenberg, 1981), and they integrate responses to disturbance and exposure over relatively long periods of time (months to years). Their sensitivity to pollutant stress is, in part, because they live in sediment that accumulates environmental contaminants over time (Nixon, et al., 1986), and because they are relatively immobile.

Reference sites were used to calibrate the indices similar to the approach used to calibrate fish IBI scores in fresh water ecosystems. The references cited above describe the approaches used for calibration and scoring in various estuarine provinces. These indices were calibrated for the respective estuarine province in which they were developed. While the development and calibration process was similar among provinces, the specific thresholds reflect the estuarine conditions within that province. In general, good condition means that less than 10 percent of the coastal waters have low benthic index scores. Fair condition means that between 10 and 20 percent of the coastal waters have low benthic index scores. Poor condition means that greater than 20 percent of the coastal waters have low benthic index scores.

What the Data Show

Benthic community index scores have been assessed for the Northeast, Southeast, and Gulf Coastal Areas. For the Northeast, Southeast, and Gulf Coastal areas, 56 percent of the coastal waters were assessed in good condition, 22 percent in fair condition, and 22 percent in poor condition based on benthic index scores (Exhibit 5-35).

Associations of biological condition with specific stressors indicate that, of the 22 percent of coastal areas with poor benthic condition, 62 percent had sediment contamination, 11 percent had low dissolved oxygen concentrations, 7 percent had low light penetration, and 2 percent showed sediment toxicity (EPA, ORD, OW, September 2001).

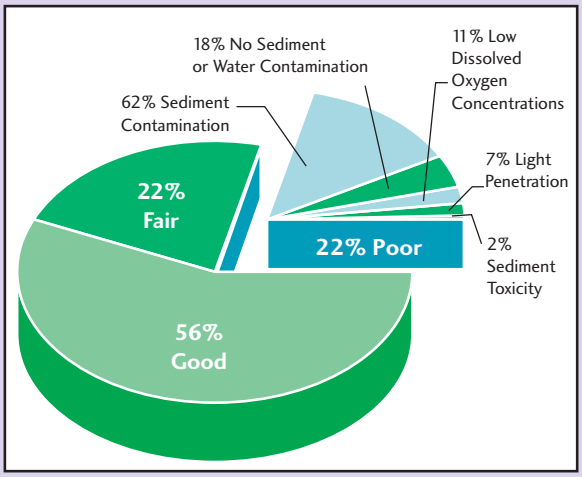
Indicator Gaps and Limitations

Benthic community index scores have been assessed only for the Northeast, Southeast, and Gulf Coastal areas. Samples have been collected in all coastal areas, including Alaska, Hawaii, and Island Territories, but these data have not been assessed. A complete assessment of coastal condition is anticipated in 2003.

Data Source

The data source for this indicator was *National Coastal Condition Report*, U.S. Environmental Protection Agency, September 2001, using data from the Environmental Monitoring and Assessment Program, Estuaries Program. (See Appendix B, page B-46, for more information.)

Exhibit 5-35: Benthic Community Index (BCI) scores for coastal waters in good, fair, or poor condition, 2000



Coverage: Northeast, Southeast, and Gulf Coastal areas

Source: EPA, Office of Research and Development and Office of Water. *National Coastal Condition Report*. September 2001.

Indicator: Fish diversity - Category 2

Fish diversity is considered to be an indicator of ecological condition because fish integrate effects of environmental stress over space and time (EPA, ORD, September 1998). For this indicator, fish collected by trawling are identified, enumerated, and measured, allowing assessment of native and non-native species, diversity, abundance, pollution-tolerant/intolerant, and size class (e.g., young-of-year and adults).

This indicator provides data for the mid-Atlantic estuaries. Because fish catch data are sensitive to different sampling gear, no critical thresholds were established for the mid-Atlantic estuaries. High and low diversity were arbitrarily established as: high > 3 fish species in a standard trawl; low ≤ 3 fish species in a standard trawl (EPA, ORD, May 2003).

Data Source

The data source for this indicator was the *Mid-Atlantic Integrated Assessment, MAIA-Estuaries, 1997-1998 Summary Report,* U.S. Environmental Protection Agency, May 2003.
(See Appendix B, page B-46, for more information.)

What the Data Show

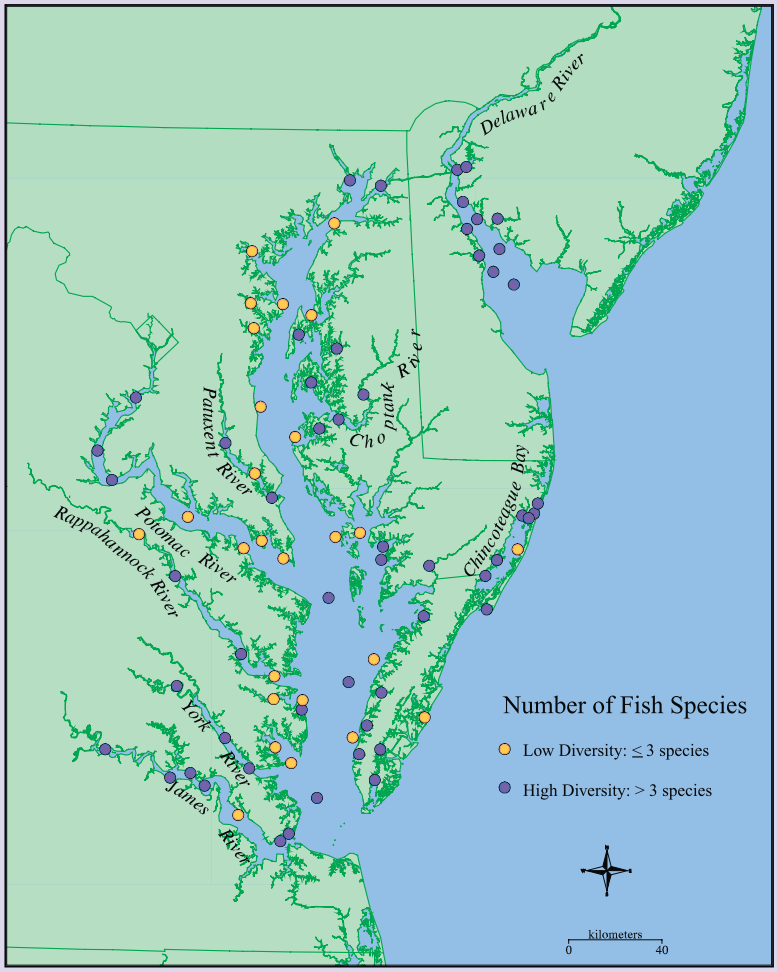
In 1998, out of 110 sampling sites selected for the mid-Atlantic estuaries in 1998, fish trawls were conducted at 80 sites (the others were too shallow to trawl). The fish species count ranged from 0 to 13, with an average of 4.6 species per site (Exhibit 5-36). For the mid-Atlantic estuaries in general, more fish species were found in upper Delaware Bay, the coastal bays, and in the upper portions of tributaries. Fewer species were evident in the Chesapeake Bay mainstem and lower tributaries.

Indicator Gaps and Limitations

The limitations of this indicator include the following:

- Fish diversity estimates are available only for the mid-Atlantic estuaries.
- While fish diversity can be determined for each sampling site, currently no context exists for interpreting the condition of estuaries from fish diversity numbers because there are no criteria or thresholds for relating fish diversity estimates to estuarine condition.
- Fish populations are highly mobile, so caution must be used in interpreting low diversity estimates for measurements observed at any individual site may not be representative of the condition of the estuary.

Exhibit 5-36: Fish diversity in mid-Atlantic bays, 1997-1998



Coverage: Mid-Atlantic bays (Delaware, Maryland, New Jersey, Virginia).

Source: EPA, Office of Research and Development, Atlantic Ecology Division. *Mid-Atlantic Integrated Assessment, MAIA - Estuaries 1997-98, Summary Report.* May 2003.

Indicator Submerged aquatic vegetation - Category 2

Many estuarine systems contain submerged aquatic vegetation (SAV), which provides habitat and refugia for fish and invertebrates, helps protect shorelines from erosion, contributes to sediment accretion, and provides food for aquatic organisms. The vegetation also stabilizes shifting sediments and adds oxygen to the water. SAV is sensitive to pollution and shading by turbid water.

In the mid-Atlantic region, Mid-Atlantic Integrated Assessment (MAIA) field crews noted the presence or absence of SAV at their sampling stations as an ancillary measurement, but no attempt was made to estimate the extent of SAV. For the Chesapeake Bay, however, SAV extent is an ecological endpoint, and restoration of SAV is one of the goals of the Chesapeake Bay Program (Batiuk, et al., 2000).

What the Data Show

Scientists estimated that historically there were about 600,000 acres of SAV in the Chesapeake Bay. A 1978 aerial survey estimated that this SAV acreage had decreased to 41,000 acres, but total acreage had increased to over 69,000 acres by 2000 (Moore, et al., 2000). Extent measures are not currently available for the rest of the nation's estuarine systems.

Indicator Gaps and Limitations

The limitations of this indicator include the following:

- SAV estimates have been analyzed and reported only for the mid-Atlantic estuaries but not for the entire U.S.
- These SAV estimates are for presence/absence only and do not indicate the density or abundance of the vegetation. More quantitative approaches using remote sensing are being used, but this information is not currently available for the entire U.S. coastline.

Data Source

The data sources for these indicators were *Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis*, U.S. Environmental Protection Agency, Chesapeake Bay Program, 2000; and *Mid-Atlantic Integrated Assessment, MAIA-Estuaries, 1997-1998 Summary Report*, U.S. Environmental Protection Agency, May 2003. (See Appendix B, page B-47, for more information.)

Indicator Fish abnormalities - Category 2

External abnormalities in fish can include lumps, growths, ulcers, fin rot, gill erosion, and gill discoloration. The cause of an abnormality is not always chemical contamination—it could also result from an injury or disease. A high incidence of such conditions could, however, indicate an environmental problem.

What the Data Show

The EPA EMAP Estuaries Program examined more than 100,000 fish from estuaries in the Virginian, Carolinian, Lousianian, and West Indian Province estuaries for evidence of disease, parasites, tumors and lesions on the skin, malformations of the eyes, gill abnormalities, and skeletal curvatures. Of all the fish examined, only 0.5 percent (454 fish) had external abnormalities (EPA, ORD, OW, September 2001). Of the fish examined, bottom-feeding fish had the highest incidence of disease, but this incidence was still low. There is no criterion for what constitutes a high or low number of fish abnormalities.

Indicator Gaps and Limitations

The limitations of this indicator include the following:

- Fish abnormality estimates are not available nationally for U.S. estuaries.
- Fish abnormalities can result from both natural causes such as injury and from chemical contamination, and the cause cannot be readily assessed.

Data Source

The data source for this indicator was *National Coastal Condition Report*, U.S. Environmental Protection Agency, September 2001, using data from the Environmental Monitoring and Assessment Program, Estuaries Program. (See Appendix B, page B-47, for more information.)

Indicator: Unusual marine mortalities - Category 2

Unusual marine mortalities are characterized by an abnormal number of dead animals in locations or at times of the year that are not typical for that species. For animals such as turtles, whales, dolphins, seals, sea lions, or similar vertebrates, where small numbers of deaths can be significant, this indicator reports the actual number of dead animals. For other more abundant animals such as fish, sea birds, and shellfish, the number of mortality events is recorded. The cause of these unusual events might include infectious disease, toxic algae, pollutants, or natural events.

What the Data Show

More than 2,500 California sea lions were involved in unusual marine mortalities in 1992, which is more than 10 times the number of seals, sea lions, sea otters, or manatees lost in similar events since 1992 (The Heinz Center, 2002) (Exhibit 5-37). The next two largest events were the deaths of 150 manatees off the Florida coast in 1996 and the deaths of 185 California sea lions in 1997 (The Heinz Center, 2002). No causes for these events were cited in the Heinz report (The Heinz Center, 2002).

Indicator Gaps and Limitations

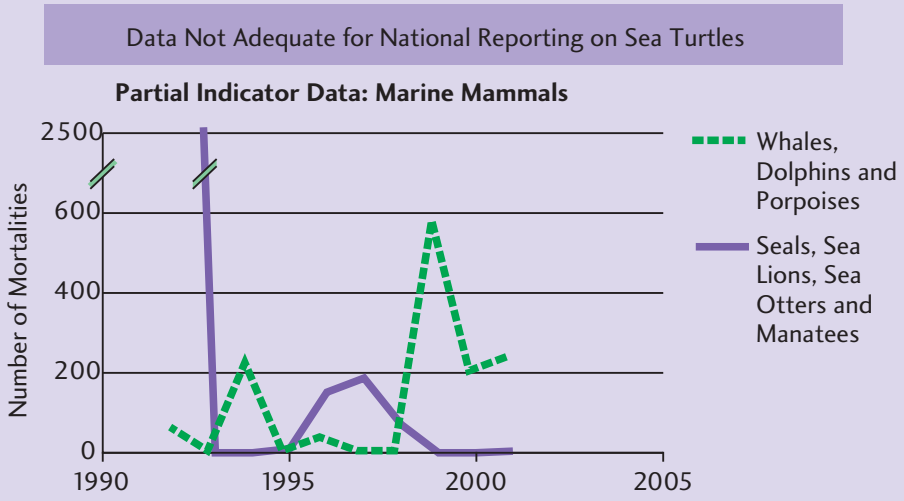
The limitations of this indicator include the following:

- This indicator represents only unusual events; it does not represent all observed mortalities of marine organisms.
- Criteria or thresholds do not exist for assessing the importance of unusual mortalities.
- It is not possible to determine if the event was caused by natural phenomena such as El Nino or was the result of anthropogenic influences.
- The data are not available on a national basis.

Data Source

The data source for this indicator was *The State of the Nation's Ecosystems,* The Heinz Center, 2002, using data from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries, Office of Protected Resources, Marine Mammal Health, Stranding Response Program, *CRC Handbook of Marine Mammal Medicine: Health, Disease, and Rehabilitation, 2nd edition* (Dierauf and Gulland, eds., 2001). (See Appendix B, page B-47, for more information.)

Exhibit 5-37: Unusual marine mortalities, 1992-2001



Coverage: all U.S. waters.

Source: The Heinz Center. *The State of the Nation's Ecosystems.* 2002. Data from the National Marine Fisheries Service and Dierauf and Gulland (2001).

Summary: The Ecological Condition of Coasts and Oceans

Coasts and oceans are subject to the same pressures as fresh waters, especially because they represent the endpoint for most fresh water drainage networks. Problems are exacerbated by the hydrology of estuaries, which tends to create conditions ideal for concentration of pollutants entering from upstream.

Landscape condition

The extent of this resource has been described by EPA and NOAA, and the landscape composition of much of the nation's coastline is known, providing a baseline against which to monitor future changes. As an example, 400,000 of 5,000,000 acres of coastal wetland were lost since the mid-1950s, although the loss rate declined in the 1990s (The Heinz Center, 2002). The baseline information is inadequate, however, for coral reefs, shellfish beds, and SAV, although a survey in Chesapeake Bay indicates that the acreage of SAV there increased from 41,000 to 69,000 acres since 1978 (Moore, et al., 2000). The estuarine landscape structure and pattern, and their contribution to ecological condition, remain inadequately measured or understood.

Biotic condition

The National Coastal Assessment, a joint federal and state interagency national monitoring program implemented to assess the ecological condition of the nation's estuaries, has developed regional data on several biotic condition indicators, including fish, benthic communities, and SAV. The program is also monitoring abnormalities and tissue contaminants. Results from three regions (Northeast, Southeast, and Gulf) indicate that, on average, 44 percent of the bottom community was in fair or poor condition, but this number varies among regions. Chlorophyll concentrations, which reflect the amount of phytoplankton growing in the water column, were over the recommended limit of 15 ppm (to protect SAV beds) over one-third of the estuarine area in the mid-Atlantic states. No similar estimates are yet available nationwide. Of more than 100,000 fish in random trawls from Maine to Texas, less than 0.5 percent showed visible evidence of disease, parasites, tumors or lesions of the skin, malformation of the eyes or gills, or skeletal curvature. Fish tissue contamination (other than non-toxic arsenic) was found in about 4 percent of fish.

Chemical and physical characteristics

A number of physical and chemical indicators are being monitored in estuarine systems to help diagnose and interpret biotic condition information. Data are available only for estuaries on the Atlantic or Gulf coasts, but 18 percent of mid-Atlantic estuaries were judged to have high nitrogen concentrations (which can lead to harmful algal blooms), and 12 percent had high concentrations of phosphorus. Twenty percent of Atlantic and Gulf estuaries had low dissolved oxygen concentrations (<5 ppm). On average, 75 percent of the sediments had elevated pesticide concentrations, and 40 percent had elevated concentrations of heavy metals, again with significant variation from region to region. Ten percent of the sediments showed a positive response to toxicity tests using a marine amphipod. Only 4 percent of the estuaries had poor light penetration.

There were no Category 1 or 2 indicators of *ecological processes*, *hydrology and geomorphology,* or *natural disturbance regimes* available for this report. The dearth of indicators for ecological processes is likely due, in part, to the fact that these indicators typically require repeated visits over several days, which makes systematic sampling in estuaries time-consuming and expensive. Procedures using remote sensing to assess ecological processes are being developed, but these are not ready for national or regional implementation. Hydrologic indicators may be similar to those for fresh water systems, but are complicated by the complex flows caused by tides and other phenomena in estuaries. An indicator of sea level change also may be useful. Storms, hurricanes, and similar disturbances are monitored globally, nationally, regionally, and locally, but this information has not been developed in the form of an indicator.

Information on disturbance regimes could also be used to partition observed estuarine system responses into portions attributable to natural versus anthropogenic disturbances.